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(54) **Dynode substrates**

(57) In discrete dynode channel plate electron multipliers, for use, for example, as raster intensifiers in a cathode ray tube, the dynode plates 2,3 are perforated mild steel sheets as used for shadow masks in colour television tubes. The steel sheets are coated with an oxidised chromium layer which will bond well to glass, be thin enough not to degrade the mechanical key provided by the etched steel, be oxidiseable at a low temperature to avoid stress relieving the steel, and which will also provide an effective barrier to the migration of iron from the steel into a secondary emitter 5, degrading its performance. A layer of evaporated chromium 0.1μm thick has been found to be suitable in all these respects. A stack of such plates is bonded together but electrically insulated from one another, preferably with glass 4, to form the multiplier, the insides of the perforations being coated with the secondary emitter 5.

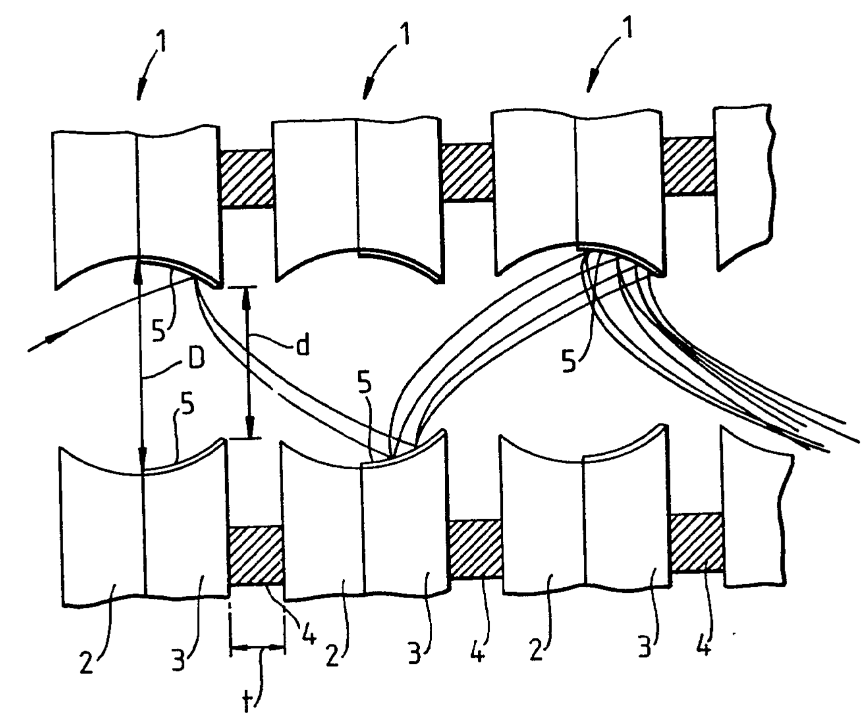

Fig.1.

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The drawing(s) originally filed was/were informal and the print here reproduced is taken from a later filed formal copy.

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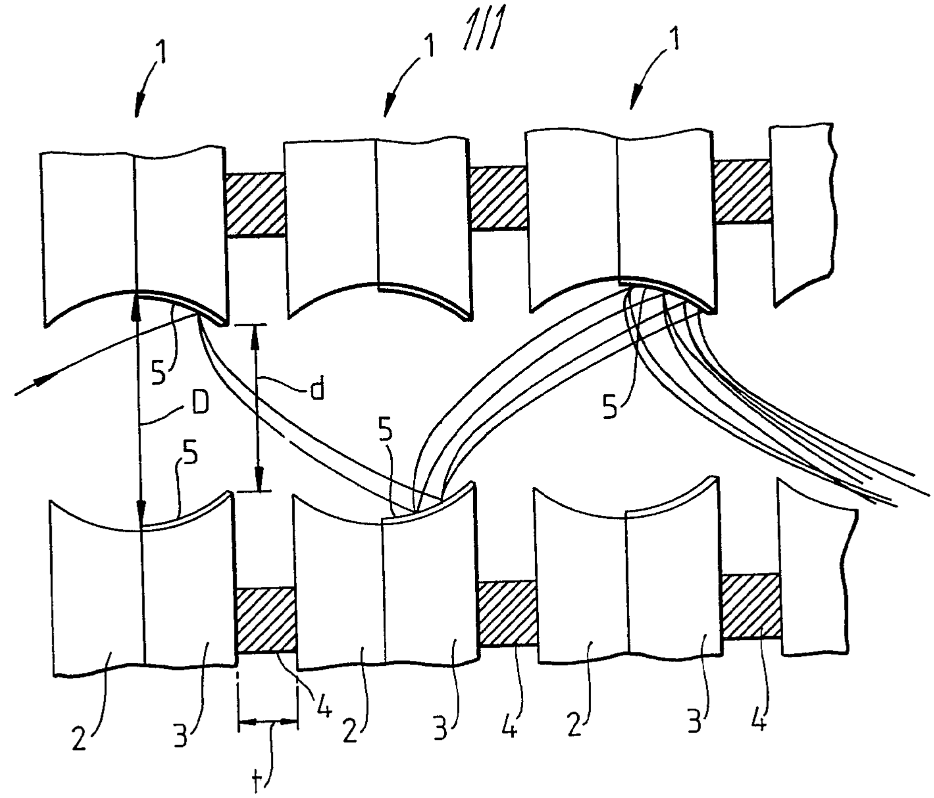

Fig.1.

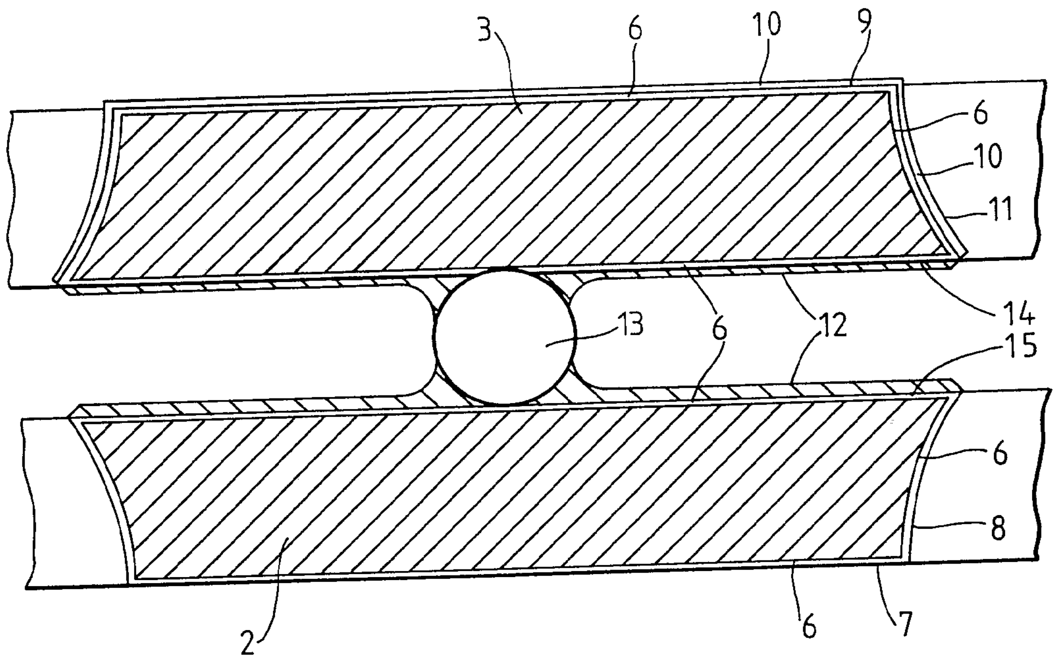

Fig.2.

SPECIFICATION

Dynode substrates

This invention relates to a substrate bearing a secondary-emissive layer for use in discrete dynode channel plate electron multipliers. More particularly it relates to a mild steel substrate which is to be bonded to but electrically insulated from other such substrates. In a perferred construction the plate dynodes have re-entrant apertures as described in Patent Specification No. 1,434,053 in which each dynode may be made out of two half-dynode plates comprising mating mild steel plates having dome-shaped holes which mate with the larger apertures of the holes in contact. In this construction one-half dynode bearing the secondary emitter is bonded to, but electrically insulated from, the half dynode of the next dynode, which half-dynode may have no secondary emitting layer but which cooperates with adjacent half-dynodes to produce an electrostatic field between the dynodes which guides electrons from one emitting half-dynode to corresponding areas of the emitting half-dynode of the next state.

Glass is a suitable material for bonding the two-half dynodes together and for achieving the electrical insulation. The perforated mild steel shadow masks produced for colour television display tubes are suitable for use as dynodes as described in Patent Specification 1,434,053. To obtain a strong bond between the steel and the glass, an oxidised metal coating on the dynode is desirable. Chromium oxide is well known as a suitable material for bonding to glass. The oxidised metal coating must also deposit well upon etched steel and evaporated chromium or chromium oxide is known to be satisfactory in this respect. However, should the metal chosen for the coating need to be heated to produce the oxide layer, it is important that the temperature at which oxidation is carried out should be comparatively low, that is not above 600°C, and preferably as low as 500°C, rather than 750°C to 900°C as might be required when oxidising the steel. If the temperature of oxidation is too high, the dynodes become distorted due to stress relief and also become pliable rather than remaining resilient.

In addition to providing an oxidised metal coating for glass bonding on one surface of the secondary-emitting half dynode, a diffusion barrier layer must be provided on the inside of the dome-shaped hole of this dynode. This barrier is to prevent degradation of the secondary emitting layer, placed on the walls of this hole, by diffusion of iron from the steel dynode into the secondary emitter during later stages of processing which involve heating. In Patent Specification No. 1,523,730 the use of nickel, or nickel-chromium alloy, of 2 μm thickness as a barrier layer is described. However evaporated nickel can give poor bonding to enamel glasses even when previously oxidised. The nickel layer produced by the immersion or replacement process used in the enamelling industry produces a very thin layer which does not function well as a barrier to iron.

The invention provides a substrate bearing a secondary emissive layer for use in discrete dynode channel plate electron multipliers, the substrate comprising a perforated steel plate, an evaporated layer of chromium metal laid down on all surfaces of the plate, the exposed surface of which chromium layer is oxidised, and an evaporated layer of secondary emissive material on the chromium oxide surface within the perforations of the steel plate.

The substrate may be bonded to, but electrically insulated from, a correspondingly perforated mild steel field plate. The smaller diameter apertures on the two plates are adjacent and in registration with one another. The field plate has a layer of chromium on the side having smaller diameter apertures, the exposed chromium surface being oxidised, and the bonding of the two plates is effected via a layer of enamel glass on each of the adjacent oxidised chromium surfaces of the two plates. The two layers of enamel glass may be bonded to one another via small glass spheres, termed ballotini, as is described in European Patent Application 79200291.7, published under European Number 0,006,267. A stack of such bonded pairs of plates is assembled to form a discrete dynode channel plate electron multiplier, the larger diameter apertures of a field plate of one bonded pair of plates being adjacent to, in registration with, and in electrical contact with the larger diameter apertures of the succeeding secondary emissive plate of the next bonded pair of plates.

To assist in achieving a good mechanical key between the glass and the steel plate, the latter may be etched to provide a rough surface. to preserve this key, the evaporated metal layer applied to the steel to provide a barrier protecting the secondary emitter and, when oxidised, to provide a good bond to glass on other parts of the substrate should be as thin as possible to avoid filling in and smoothing the crenellations of the etched steel surface. However, the evaporated metal layer should remain an effective barrier to iron diffusion. Unexpectedly, chromium has proved excellent in this respect and the chromium layer may have a thickness of 0.1 micrometers, at which very little filling-in of the etched steel surface occurs.

An embodiment of the invention will now be described, by way of example, with reference to the accompanying drawing in which:—

Figure 1 shows in section a few stages of a discrete dynode channel plate electron multi-

pler, and

Figure 2 shows a section of part of an emitting half-dynode bonded to a field half-dynode via glass enamel on the half-dynodes and a glass sphere.

In Fig. 1 each dynode 1 comprises a field half-dynode 2 in electrically conducting contact with an emitting half-dynode 3. Each half-dynode is a perforated mild steel similar to those produced for shadow-masks for colour television display tubes and is typically 150μm thick. The perforated holes are dome-shaped, the larger aperture diameter D being typically 420μm, the smaller diameter d being 300μm. Pairs of field and emitting half-dynodes are bonded together on the sides of small hole diameter via an electrically insulating spacer 4, of thickness t, typically 100μm. A secondary electron emissive layer 5 is provided on the inside of each hole of each emitting half-dynode by evaporation. A channel plate electron multiplier is assembled as a stack of such half-dynode pairs with the larger diameter apertures in contact, as shown in Fig. 1.

Fig. 2 shows a bonded pair of half-dynodes in more detail. The half-dynodes 2 and 3 have a 0.1μm thick layer 6 of chromium metal evaporated onto both sides and within the holes of the steel surface which has been roughened by etching to provide a good mechanical key for a subsequently applied glass enamel coating. On the lower surface 7 and in the hole 8 of field half-dynode 2 and on the upper surface 9 of emitting half-dynode 3, the chromium layer serves to protect the steel from oxidation during storage in air. The chromium layer 6 is oxidised by firing for one hour at a temperature of 600°C in a mixed gas atmosphere of 25% hydrogen and 75% nitrogen made moist by bubbling through water at room temperature. After oxidising, the half-dynodes 3 and 2 are coated with glass enamel 12 on surfaces 14 and 15 either overall or in an array of patches. The secondary emissive layer 10 is then evaporated onto the upper surface 9 and inside the hole 11 of half-dynode 3. The secondary emissive layer may be, for example, a gold-cryolite mixture as is described in Patent Specification 1,523,730. Half-dynodes 2 and 3 are then bonded together via an array of glass spheres, or ballotini, one of which is shown at 13 in Fig. 2. This method of bonding and insulating half-dynodes is described in published European Patent Specification 0,006,267.

The thin oxidised chromium layer 6 on the etched steel surface provides a good mechanical key and a good chemical bond for the glass enamel 12. The metallic chromium beneath the chromium oxide on dynode 3 provides an effective barrier against migration of iron from the steel dynode into the secondary emissive layer, which would otherwise degrade its secondary emission coefficient.

CLAIMS

1. A substrate bearing a secondary emissive layer for use in discrete dynode channel plate electron multipliers, the substrate comprising a perforated steel plate, an evaporated layer of chromium metal laid down on all surfaces of the plate, the exposed surface of which chromium layer is oxidised, and an evaporated layer of secondary emissive material on the chromium oxide surface with the perforations of the steel plate.

2. A substrate as claimed in Claim 1, wherein the perforations are dome-shaped holes which each have a larger diameter aperture on one side of the plate than on the other.

3. A substrate as claimed in Claim 2, bonded to, but electrically insulated from, a correspondingly perforated mild steel field plate, the smaller diameter apertures on the two plates being adjacent and in registration with one another, said field plate having an evaporated layer of chromium on the side having smaller diameter apertures, the exposed chromium surface being oxidised, and a bonding layer of enamel glass on each of the adjacent oxidised chromium surfaces of the two plates.

4. A substrate as claimed in any one of the preceding claims, wherein said chromium layer has a thickness of 0.1 micrometers.

5. A substrate as claimed in any one of the preceding claims wherein the surfaces of the steel plate are etched before the chromium is applied.

6. A discrete dynode channel plate electron multiplier comprising a stack of substrates as claimed in Claim 3 or any claim appended to Claim 3, the larger diameter apertures of a field plate of one bonded pair of plates being adjacent to and in registration with the larger diameter apertures of the succeeding secondary emissive plate of the next bonded pair of plates.

7. A substrate for use in discrete dynode channel electron multipliers substantially as described with reference to the accompanying drawing.

8. A method of manufacturing a substrate as claimed in Claim 1, substantially as hereinbefore described with reference to the accompanying drawing.

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